

Selecting energy-efficient windows



Glass and Glazing Federation



ENERGY EFFICIENCY

**BEST PRACTICE
PROGRAMME**

ARCHIVED DOCUMENT

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INTRODUCTION

Double-glazed windows are now a normal part of most housing refurbishment packages and provide many benefits over single glazing. There are, however, several improvements that can be made to the thermal performance of standard double glazing.

Modifications such as wider air gaps, special coatings and use of inert gases can offer significant benefits over standard double glazing. These features must, however, be specified at the time of replacement so that the opportunity for providing these benefits is not lost.

This Guide will enable specifiers to understand the factors affecting the energy performance of windows and help them to select the most appropriate specification.

Higher thermal performance glazing out-performs standard double glazing in a number of areas.

- **Heat loss and fuel bills.** These are significantly reduced and can also lead to less pollution, because carbon dioxide (CO₂) emissions are reduced.
- **Comfort.** Warmer internal surfaces reduce cold down-draughts, allowing similar comfort levels for householders at lower air temperatures. This is perhaps one of the most important benefits of improved glazing specifications.
- **Condensation.** This type of window has an even lower risk of condensation.
- **Reduced heating system.** In some situations higher specification glazing may enable smaller boilers or radiators to be installed, so reducing capital costs.

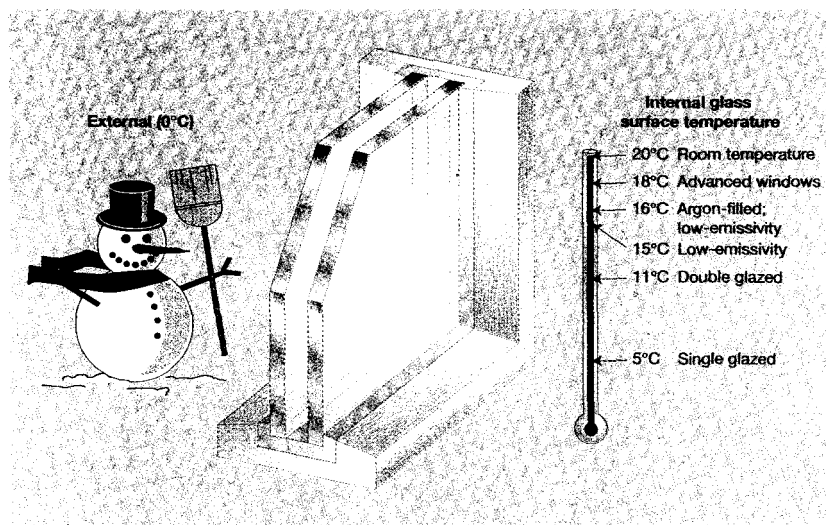


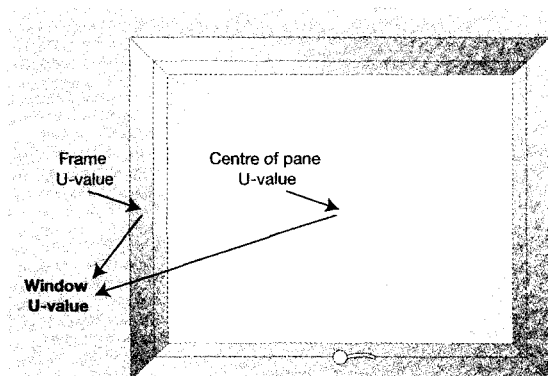
Figure 1 Improving the thermal performance raises the surface temperature of the inner pane of glass and improves occupant comfort

The performance and U-values (see box below) of a window can be improved by addressing several components or factors:

- glass and glazing unit – number and size of air gaps, use of coatings, and type of gas fill
- frame type and design – construction and material, frame strength, and draughtstripping
- specification and installation – prevention of air infiltration, distortion, and thermal bridging.

This Guide addresses these three areas, and includes tabulated data to assist with window selection.

Although standard double-glazed windows offer many benefits compared to single glazing, several other significant improvements can be made



MEASURING THERMAL PERFORMANCE – AND WINDOW U-VALUES

It is normal for the thermal performance (U-value) of glazing units to be measured at the centre of the unit (known as 'centre of pane'), as illustrated left. The U-value of the window makes allowances for the window frame and the edge seals. Typical window U-values are listed in the table on page 7.

GLASS ISSUES

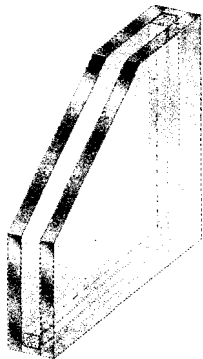


Figure 2 Part of an hermetically sealed unit

In their simplest form, sealed double glazing units consist of two panes of glass separated by an air gap or 'cavity'. A spacer bar runs around the edge of the unit and the cavity is hermetically sealed (figure 2). The cavity is usually filled with dehydrated air.

Figure 3 illustrates how heat is lost through windows by a combination of:

- conduction through the glass
- convective air movement over the glass surface
- long wave (infrared) radiation from surfaces within the room and between the panes.

In addition heat is also lost through and around the frame.

There are a number of ways of raising the performance of glazing units, and while each of the improvements listed below can be made

individually they are usually considered incrementally in the order given, as follows.

Cavity width

Increasing the width of the cavity between the panes of glass will reduce the conductive losses and improve performance. But if the gap becomes too large then convection currents can form which will offset this improvement. Figure 4 shows the relationship between cavity width and performance. The optimum cavity is approximately 16-20 mm but cavities of 12 mm are a good compromise where the choice of window frame limits the size of the glazing unit.

Double glazing units are usually specified in terms of glass and air gap width. (For example, standard double glazing is '4-6-4' which means 4 mm glass-6 mm air gap-4 mm glass.)

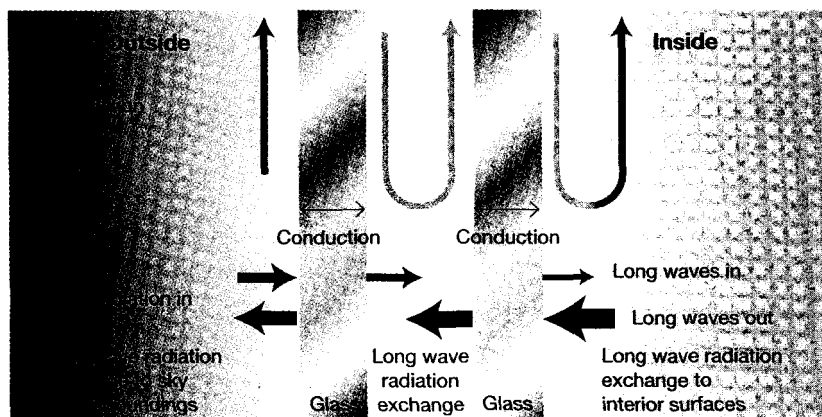


Figure 3 Heat is lost through windows by conduction, convection and long wave radiation

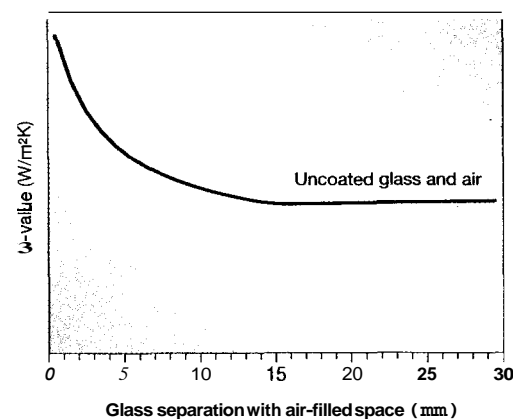


Figure 4 The optimum cavity width for double-glazed panes is approximately 16-20 mm, although 12 mm is acceptable

GLASS ISSUES

Low-emissivity glass

Low-emissivity (low-e) glass has a microscopically thin coating applied to one glazing surface as part of the manufacturing process. As the coating does not affect visible radiation it is transparent to the eye. However, longer wavelength radiation – heat that is radiated from surfaces in a room – is not transmitted through the coating, but reflected back into the building, so reducing heat loss.

The coating is applied to surface 3 (see figure 5), so the surface temperature of the inner pane is higher than with standard double glazing and this reduces the risk of condensation. This also means that heat reflected by the coating is radiated into the room, increasing the comfort levels close to windows.

Additional coatings applied to other surfaces of the glazing unit will further improve the thermal performance.

Early low-e glass had a tint, but in new glazing units this effect is barely noticeable unless compared directly with uncoated glass. Consequently, low-e and plain glass should not be mixed within a single room.

Gas filling

In a gas-filled unit (figure 6) the air in the glazing unit is purged during manufacture and is replaced with an inert gas such as argon. Inert gases have a lower thermal conductivity than air so they help to suppress convection within the unit, reducing heat loss.

Triple glazing

Triple glazing has the effect of allowing a larger insulating air gap while preventing the convective losses that can occur in an equivalent single air space. When used without special coatings and

inert gases, triple glazing is comparable to double glazing with low-e, but the addition of coatings and inert gases will improve the performance beyond that achievable by double glazing.

With triple glazing, care should be taken to ensure that the frame is strong enough to withstand the additional weight of the extra glass.

Some specialist UK companies do manufacture triple glazed units and frames to hold them, but they are more often sourced from abroad.

Advanced glazing

Very-high-performance glazing with U-values of less than $0.8 \text{ W/m}^2\text{K}$ (centre of pane) can be created using three or four panes of glass with different combinations of coatings and gas-fills. Thin films of coated polymers suspended between outer and inner panes can be used instead of glass. In some designs one pane of glass is installed in a separate sub-frame (see frame design, page 6).

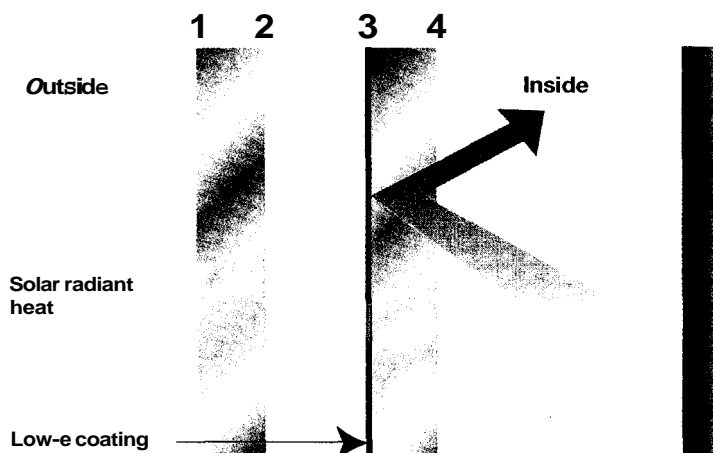


Figure 5 The low-e coating on surface 3 reflects longer wavelength radiation back into the room, reducing heat loss

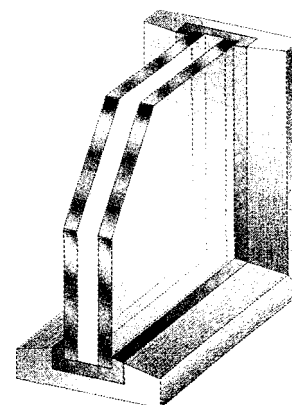
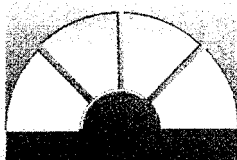


Figure 6 Inert gases suppress convection so reducing heat loss

FRAME DESIGN



DOORS

Insulated doors which achieve a U-value of less than $1 \text{ W/m}^2\text{K}$ (without glazed areas) are readily available and should be considered at the time of replacement. Glazing units within doors can be made to the same specification as those for windows.

The four key factors in frame design which can influence the performance of a window are listed below.

In addition, there can be significant heat loss caused by air movement between elements of the frame, and also between the frame and the wall opening.

Frame design and materials

The choice of timber, PVC-U or aluminium frame will often be influenced by other factors such as aesthetics and maintenance. All are suitable for use with double glazing systems. However, when specifying aluminium units, care should be taken to avoid thermal bridge problems. This can be achieved by specifying that thermal breaks must be inserted between frame elements. It is also important that the thermal breaks in different frame sections line up in order to minimise thermal bridging (see figure 7).

Ideally, two separate draughtstrips should be installed and, where possible, each draughtstrip should consist of a single length of material with the joint at the window head. If this is not practical (for example, where draughtstrip is clamped as part of the manufacturing process in aluminium windows) care must be taken to prevent ingress of moisture and insects by ensuring that there are no gaps between the lengths of draughtstrip – particularly at corners.

In order to ensure adequate compression, window casements must line up with draughtstrips. This is particularly important with friction hinges. A simple check is to ensure that edges to openings are parallel to mullions (all frame types) and that mitres on opening casements meet at frame corners (aluminium and PVC-U windows only), as shown in figure 8.

Correct specification and installation of hardware (hinges, locks etc) is also important for ensuring compression of draughtstrips. Multi-point locking should be used where the length of the opening light is greater than 800 mm.

Ventilation

Having stopped uncontrolled (adventitious) ventilation through good draughtstripping, controlled ventilation should be provided either within the window units (usually through the incorporation of trickle ventilators) or by other means, eg air vents or mechanical ventilation. Location and size of trickle vents should be discussed with the manufacturer to ensure that frames are not weakened by badly positioned vents.

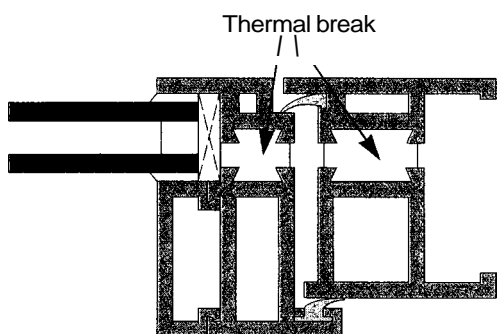


Figure 7 Thermal breaks should line up to minimise thermal bridging

When triple glazing or advanced glazing is being used, the performance of all three frame materials can be improved by fixing a sub-frame, incorporating thermal breaks on to the main frame to take the third or fourth glazing layer. This can be mounted internally or externally.

Frame strength

The frame must be designed to support the weight of the glazing unit. If the frame is not strong enough it will distort and place stresses on the glazing unit causing it to fail prematurely. This will result in a loss of performance in the window as a whole. The frame may also fail to close properly against the draughtstrip leading to heat loss through excess ventilation.

Draughtstripping

Window frames should be designed with integral draughtstripping (which can be factory-fixed or site-fixed) and should achieve adequate compression of the draughtstrip along its entire length.

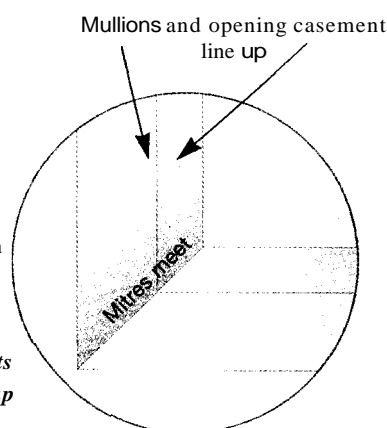


Figure 8 Check to ensure casements and draughtstrips line up

ENERGY SAVINGS CALCULATOR

	Glazing	Window U-value* W/m²K	Savings** £/yr		kWh/yr	
			from single** (U = 1.7)	from standard double (U = 1.3)	from single** (U = 1.7)	from standard double (U = 1.3)
Terrace Floor area 79 m² Window area 12.7 m²	❶ = enlarged air gap (4-12-4)	3.0	30-35	5	1950-2300	350
	❷ = ❶ + low-e	2.4	35-45	10-15	2300-2950	650-975
	❸ = ❷ + argon fill	2.2	45-50	15-20	2950-3250	975-1300
	❹ = advanced windows	1.5 or better	55-65	25-35	3600-4250	1650-2300
Semi-detached Floor area 89 m² Window area 16.9 m²	❶	3.0	40-50	5	2600-3250	350
	❷	2.4	50-60	15-20	3250-3900	975-1300
	❸	2.2	55-65	20-25	3600-4250	1300-1650
	❹	1.5 or better	70-80	30-40	4550-5200	1950-2600
Detached Floor area 148 m² Window area 25.6 m²	❶	3.0	65-75	10	4250-4900	650
	❷	2.4	75-85	20-25	4900-5550	1300-1650
	❸	2.2	85-95	25-35	5550-6200	1650-2300
	❹	1.5 or better	110-120	50-60	7150-7800	3200-3850

*Taken from Building Regulations Approved Document L (except advanced windows). Some variation with frame type.

**Energy savings are estimated using BREDEM v12 for a range of standard house types with gas heating, and assumes a standard occupancy and heating regime (weekdays 2 hours am; 7 hours pm; weekends 16 hours each day).

***Assumes no draughtstripping. All other glazing options include draughtstripping.

SPECIFICATION AND INSTALLATION

Window units need to be specified and installed correctly if they are to perform properly. Particular care should be taken in the following areas.

- Ensure frames are specified and installed to maximise the life of the glazing unit (and therefore thermal performance). For example:
 - use a drained and/or ventilated glazing method to ensure that water cannot be trapped against the edge seal for prolonged periods
 - if a fully bedded sealing method must be used, ensure that water is shed away from the glass
 - protect the edge seal from direct sunlight by ensuring that the rebate is of sufficient depth.

- Ensure that gaps between window frames and walls are filled with expanding foam around the entire perimeter, while not interfering with any drainage paths.
- Where frames are site-glazed check that low-e glass is installed the correct way around (usually indicated by a label).
- Position window frames in the structural reveals so as to minimise the risk of thermal bridging through wall details.

More detailed guidance is given in 'Thermal bridging: avoiding risks', and section 4.2 of the GGF Glazing Manual (see below for details).

FURTHER READING

DETR ENERGY EFFICIENCY BEST PRACTICE PROGRAMME DOCUMENTS

The following Best Practice publications are available from BRECSU Enquiries Bureau. Contact details are given below.

General Information Leaflet

9 Domestic ventilation

Good Practice Guide

139 Draughtstripping of existing doors and windows

OTHER PUBLICATIONS

Building Research Establishment. 'Thermal Insulation: avoiding risks'. BRE, Garston, 1994

'Selecting windows by performance' BRE Digest 377, BRE, Garston

'PVC-U Windows' BRE Digest 404, BRE, Garston

'Double glazing units - a BRE guide to improved durability' Report 280, BRE, Garston, 1995

Glass and Glazing Federation. 'Glazing Manual.' GGF, London, 1995
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Energy Efficiency provides information on energy efficiency measures that are disseminated through various channels and other means of communication.

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General Information: describes concepts and approaches yet to be established as good practice.

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